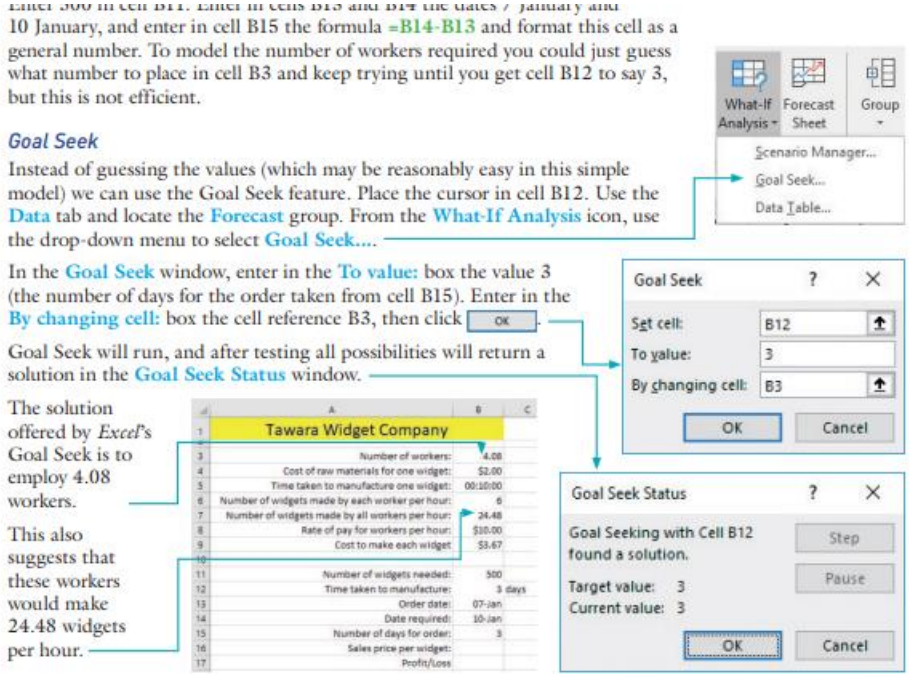
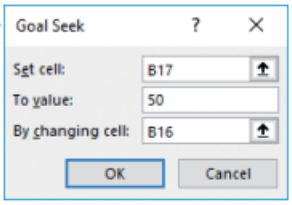
9 Modelling

9.1 What-if analysis

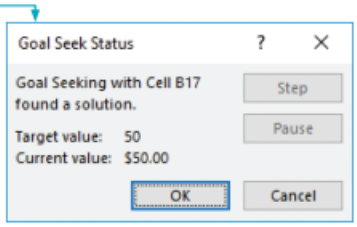
- Computer models all base their model upon a what-if analysis which involves changing a mode to find out what the results would be, if different input values are changing.
- It is basically asking a question such as *what* will happen *if* I perform a certain action
- Goal Seek feature is a what-if analysis tool that enables you to find the input values needed to achieve a goal or objective making what-if analysis more precise
- To use Goal Seek, you select the cell containing the formula that will return the result you are seeking.
- You then input the value you want the formula to return and enter the cell reference of the input value that the spreadsheet can change to reach the target


10 January, and enter in cell B15 the formula =B14-B13 and format this cell as a general number. To model the number of workers required you could just guess what number to place in cell B3 and keep trying until you get cell B12 to say 3, but this is not efficient.
Goal Seek
Instead of guessing the values (which may be reasonably easy in this simple model) we can use the Goal Seek feature. Place the cursor in cell B12. Use the Data tab and locate the Forecast group. From the What-If Analysis icon, use the drop-down menu to select Goal Seek....
What-If Analysis
Forecast Sheet
Group
Scenario Manager...
Goal Seek...
Data Table...
In the Goal Seek window, enter in the To value: box the value 3 (the number of days for the order taken from cell B15). Enter in the By changing cell: box the cell reference B3, then click OK.
Goal Seek will run, and after testing all possibilities will return a solution in the Goal Seek Status window.
Goal Seek
Set cell: B12
To value: 3
By changing cell: B3
OK
Cancel
The solution offered by Excel's Goal Seek is to employ 4.08 workers.
This also suggests that these workers would make 24.48 widgets per hour.
Tawara Widget Company
Number of workers: 4.08
Cost of raw materials for one widget: $2.00
Time taken to manufacture one widget: 00:10:00
Number of widgets made by each worker per hour: 6
Number of widgets made by all workers per hour: 24.48
Rate of pay for workers per hour: $10.00
Cost to make each widget $3.67
Number of widgets needed: 500
Time taken to manufacture: 3 days
Order date: 07-Jan
Date required: 10-Jan
Number of days for order: 3
Sales price per widget:
Profit/Loss
Goal Seek Status
Goal Seeking with Cell B12 found a solution.
Target value: 3
Current value: 3
Step
Pause
OK
Cancel
q4w22/p12

To produce a realistic working solution, the number of workers will need changing to 5 which will change the contents of cell B7 to 30. To calculate the sales price required per widget to make a $50 profit, place the cursor into cell B17, then from the Data tab select the What-If Analysis icon, then Goal Seek.... Edit the Goal Seek window to look like this.



Click OK to run the Goal Seek. Goal Seek will run, and after testing all possibilities will return a solution in the Goal Seek Status window.



This returns in cell B16 a value of 3.76666666666667, which needs to be rounded up to $3.77 (it may appear to hold this already if you have formatted the cell to two decimal places). Change the value in cell B16 to $3.77 which will return a profit of $51.67.

Advice

Remember, formatting to a number of decimal places does not change the original value.

9.2 The characteristics of modelling software

- **Replication** means you don't have to enter the same formula or data several time
- **Absolute and relative referencing** makes sure you only increment parts of a formula you when to when replicating a formula
- Allows **what-if questions** to be asked
- The use of **cell protection**, it ensures that the cells which are crucial to your model are not changed accidentally by someone using the software
- **User interface forms** allows easy entry of values into model by showing clearly where the data needs to be entered
- **Macros**, it allows keystrokes you make on your keyboard to be stored which makes it easier to create more complex formulae or function
- **Goal seek** can be used to determine which variable need to be changed to achieve a target or goal
- **Pre-written functions** allow user to create complex formulae
- **Automatic recalculation**, allows data to be automatically recalculated when altered
- **Conditional formatting**, allows you to instantly highlight certain values that match specific criteria.
- **Use of graphs or charts**¸ makes it easier to show trends/predictions over a given period of time.

9.3 The need for computer models

Cost

- We need models because of costs

- If engineers are designing structure such as bridges and high-rise buildings or designing cars and planes it is very expensive to correct mistakes
- If a computer model is used, then the costs of any mistakes practically disappear.

Testing

- For the ability to test the design
- It would be impossible to build several types of buildings just to see which is most likely to survive a crash
- However, it can be done relatively easy with a computer model

Prediction

- It is impossible to travel through time, so in order to predict events over a large time span, such as climate change r population growth, computer models are used as they are the best way of making predictions
- Another use of computer models is to accurately predict when storms will occur and the severity of them, thus enabling early warning to the public about how to protect themselves and their property

Time-Efficiency

- Modelling saves time as well as money.
- Car manufacturers can perform more tests in a shorter space of time with a computer model than by arranging tests of prototypes with crash-test dummies inside them over and over again.
- Computer models make it possible to run many more tests.

Planning

- Simulations are a specific type of computer model and are very useful in planning for rare or unexpected events
- For example, they can be used to help predict and plan for the after-effects for natural disasters, such as volcanic eruptions, earthquakes and tsunamis

Safety

- Some situations are dangerous, such as experimenting with a nuclear reactor.
- A computer model is a much safer way to do this.

9.4 The effectiveness of spreadsheet models

Benefits

- Spreadsheet models can do complex calculations
- Calculation can be performed much quicker than if you were writing them or using a calculator as the formulae are recalculated automatically.
- Data can be automatically imported into a spreadsheet from a database, saves the trouble of having to manually input data
- Spreadsheet models are very useful for observing patterns which take place over a long period of time, especially for studying animal population growth
- Automatic updating of graphs
- They can remove human fallibility; the likelihood of decisions being made based on personal feelings is no longer a problem.
- Decisions made by spreadsheets are consistent for the same inputs making it reliable.
- Templates exist for regularly used spreadsheets which saves time as fewer amendments need to be made for the particular situation. Users don't need to have great computing expertise.
- Validation rules can be built into spreadsheet models which reducing data input errors.
- Graphs that are produced to show (population growth for eg) will automatically change as old values are altered

Drawbacks

- It is very difficult to include every possible variable in a spreadsheet model which could give misleading results
- To try to account for as many variables as possible requires complex formulae which may need experts who are expensive to hire
- Producing an effective model may be time consuming
- The model can have formula replicated
- Complex (exp population) predictions may need additional software/modules which is expensive to buy
- Staff that is going to use the spreadsheet model needs to be trained which creates another expense on top of creating the model.

9.5 Uses of computer models

Financial Forecasting

- Models allow us to see the effect on the amount of profit a company makes by changing variables by making use of what-if features of spreadsheets
- It also makes use of automatic recalculation feature which prevents having to ask the computer to do the calculation every time the values used change such as price or tax of an item
- User interface forms make it easier to input quantities/costs into the model
- Conditional formatting allows you to instantly highlight particular values that matches particular criteria, such as highlighting cells that are showing a profit to a certain color like green
- Complex models allow to predict the effects of changing the rate of selling a product
- They take into account the current economic climate, its effect on customers willingness to spend money, and effect of purchase taxes when predicting the number of items which be sold over time
- This is often represented using graphs showing selling trends, they can also be used to illustrate forecasts and compare result/information such as to which good are more likely to make profits over a period of time
- Goal seek allow to perform what if analysis such as to see how many product need to be sold in order to make a specific profit
- Cell protection can be used by companies to prevent accidental changes and deletion being made to stored data by inexperienced employees
- Macros allow a company to compare the effect of different costs at the same time, as it makes it simpler to create more complex formulae or functions
- More sophisticated financial models used by government to predict future of a nation's economy
- Governments can use computer models to see how much extra money would be raised if they increase taxes
- They can change the amount of spending budget and see what effect it would have on the need to raise or decrease the tax rate

Population Growth

- A population growth computer model tries to predict the population of an organism
- It assumes that organism reproduces according to a set of rules
- There a re number of variables such as how often the organism reproduces, how many new organisms it produces each time, the limiting factors like food and water, natural death rates and types of predators

- Models provide a wat of understanding how populations of organisms change over time or when compared to each other
- Many patterns can be identified by using computer modelling
- Other studies can be made such as the age distribution within population and how it changes
- Computer models are used to calculate the maximum harvest for farmers and help with environmental conservation
- They are used to understand the spread of parasites, viruses and disease
- They are also useful when modelling the future of particular endangered species

Climate Change

- Earths climate has been monitored and records have been kept of actual values of the variable involved over a large number of years that can use to predict climate change
- This data could be input into a computer model which is a very complex program that runs on supercomputer
- It Is made up of a collection of equations representing different parts of the climate
- The variables input can be changed to see what effect they will have on the climate
- These variables could include temperature, rainfall, seal level, level of co2 in atmosphere
- The equations used together give an approximation of earth's climate
- The model can be used to predict trends and examine the effect of increasing and decreasing each variable
- When model is created it can be tested by comparing model's prediction of real data for the present year to judge its accuracy
- The accuracy Is limited by the number of years it the future the model extends
- In order to create a computer model, climatologists have to make several assumptions about how the climate works.
- Problems arise because climate is affected by a large number of variables and relating all of them together is a difficult task hence many people are skeptical about the accuracy of computer models for climate research
- Climate is also affected by technological developments and government policies and vision such as reducing the use of plastic, recycling, banning dumping of waste in sea.
- These are variables can't be predicted due to their uncertainty hence it is difficult to predict what effect they will have on the climate in future
- However, as climate scientists have more and more data and more powerful computers are being created, the models will become better able to predict climate change.

Weather Systems

- Weather forecasting used to involve several weather forecasters and days of calculation but today only one model can manage that task
- These models can help the forecasters to make more reliable predictions.
- Weather presenters sometimes refer to uncertainty of their predictions because the computer models are not in agreement
- Atmospheric model can be used in weather forecasting which allows to predict future patterns of weather
- The complex the model the more accurate forecasts it can predict which allow forecasts further into the future
- Although, Human forecasters are still needed to evaluate the results
- Weather forecasting requires the use of a lot data to predict weather effectively
- This requires input of variables that affect the weather such as atmospheric pressure, humidity, rainfall and windspeed
- It makes use of mathematical equations as well as that represent vertical air motions, temperature changes, moisture processes to calculate what the atmosphere might look like
- Since the computer models need to use reading of multiple variables and include hundreds of equations to produce a weather forecast, a lot computing power is hence required to run a computer model
- Supercomputers therefore have t be used which can store and process large amounts of data but they are very expensive
- These models can be used to compare current conditions with previous similar conditions over a period of time instantly which would have taken days previously to do so

Queue Management

- Queue management models can be used by service business to reduce its costs leading to increased profitability by managing queues effectively
- The length of time customers have to queue incurs cost to business because there is a cost associated with putting extra employees at checkouts to reduce service time
- Queue management is used to weigh up one cost against the other and provide solutions to these problems for the management of the business
- Automatic queue management systems can use people counting sensors at entrances to supermarket and checkout.
- They accurately detect the number of people in the queue and their behavior
- Build in predictive algorithms can provide information on how many checkouts will be needed to move customers through quickly

- This is done as the queues are forming and the information can be displayed on computer monitors
- A range of information is provided such as the length of the queue at any given time and how long the waiting time for customers is
- Management teams can be automatically alerted before the waiting times get too long.
- Outputs produced by such systems are the number of people entering in the supermarket, queue length, average wait time, amount of time each checkout operator is idle and total wait time
- These can be used to estimate the profits and loss related to excess waiting by customers and fast checkout service provided by the supermarket

Traffic Flow

- Free movement of traffic is affected by many factors like speed, number of heavy vehicles, number of lanes and intersection present along road
- Mathematicians and civil engineers carry out research into this subject to attempt to understand and develop a road network which causes traffic to flow smoothly with few holdups
- Traffic flow models make use of a series of complex algorithms
- Some treat each mode of transport like car, bus as unique objects while other concentrate on traffic flow characteristics such as flow, density and average speed of traffic
- Current traffic models are based on observed conditions as well as theoretical techniques to forecast the amount of traffic taking into account multiple factors such as increased vehicle use to the different modes of transport being
- However even with the use of sophisticated computer processing power it has still proved to be difficult to produce a general theory that can be applied to modern traffic as it exists in reality

Construction 5

- Computer aided design (CAD) is used by architects and engineers to create precise drawings or technical illustrations
- The CAD software can be used to create 2D drawings or 3D models
- It can be used to design structure such as bridges and buildings and generate animations and other presentational material
- It allows for the inclusion of additional information such as the dimension and descriptions of components

- If a building is being designed, a library could be used which would have parts such as doors, windows, staircase and roofs available
- CAD packages produce 3D views and different viewing angles and allow 3D walkthroughs so that the viewer can actually se inside building or other structure
- Building information modelling (BIM) is an extension of CAD that allows to create models of building that don't just include physical aspects such as walls and roofs but also heating, ventilation and air conditioning and the electrical aspect of the building
- It allows the project workers to analyze and visualize design decision long before the project stars
- BIM allows members to bring all designs including CAD models into a single database and provides cloud access to it

Advantages and Disadvantages of CAD

- It can allow user to design a part much faster than traditional drawing however work can be lost due to sudden breakdown of computers
- Using CAD makes it easier to make changes and fix errors but it takes time for user to learn how to use the software
- Different parts of design can be reused and its easier to save files of drawing in formats that allows modification for design
- Open source CADs are free but they tend be to limit which other forms of CAD can be expensive to purchase, update regularly and train workers to use its software

9.6 Simulations

- A computer simulation is when a computer is used to imitate an event as it happens in real world
- A simulation is created usually from a mathematical model which represents the real system
- It consists of computer programs which are written to include the main features of this real-world system
- The model is the representation of the system, whereas the simulation is how the system performs over time

Advantages of Simulation

- Don't have to worry about the cost of repairing and replacing damaged cars or airplanes
- You may need fewer driving or flying instructors resulting in lower costs

- Simulators can provide results that are generally difficult to measure such as reaction times
- With a simulator you can see how a system might work before you design or modify it, resulting in fewer mistakes in the system
- A simulator prevents safety problems such as injury or even death in the event of a car or plane crash
- Some events such as extreme weather conditions can be recreated fairly easily without having to wait for them to happen in real life
- Can obtain results in a short period of time regarding reactions that take a long time in real life

Disadvantages of Simulation

- Buying a simulator with a fast processor and large amount of memory can be very expensive
- The technical support for such systems can prove to be more expensive than regular servicing of airplanes and vehicles
- A driving school using a simulator from scratch will need to retrain driving instructors, costing money and taking time
- The unpredictability of human behavior means it may be impossible to create simulations that cover all possibilities
- Inaccurate output from the simulation can still occur as the formulae and functions may not accurately represent all possible scenarios
- It may make the drivers or pilots overconfident and too casual regarding their abilities
- There is sometimes not sufficient data to produce a mathematical model
- Specialist knowledge is required to analyze results which requires specialists which costs money
- Simulations may not be 100% accurate

Natural Disaster Planning

- Simulations are created to plan for natural disasters to represent the flow of floodwater and the debris it carries
- Computer modelling allows us to understand and analyze natural disasters
- Advances in computer such as high processing speed and power and advances in computer-based algorithms has made it possible to model movement of water particles that allow more accurate predictions of the effects of natural disasters such as tsunamis, floods and mudslides

- This can help town planners to build structure which can withstand such disaster and allowing emergency services to co-ordinate an efficient response
- Natural disaster models may also provide information about disaster before they occur to anticipate the likelihood and severity of natural disasters from earthquakes and hurricanes to major crop failure
- It can also be used to model what might happen in the event of a terrorist attack
- It may not be able to predict/simulate catastrophic disasters that haven't occurred before or haven't been recorded/documented
- Mathematicians have produced equations and functions which represent the behaviour of volcanoes, earthquakes and tornadoes
- These equations and functions can then be converted into computer models

Pilot Training

- Training multiple new pilots and training existing pilots to fly new aircrafts can be done cheaply and safely using a simulator
- A simulator is designed to react to a pilot's instructions just like an actual aircraft would
- A flight simulator used by airlines is a purpose-built cabin
- It simulates difficult situations and take off scenarios such speed of wind, turbulence and weather conditions
- It includes software and specialized hardware that can cost hundreds of pounds such as a cabin containing screens, flight controls, control wheel, joystick, pilot seat, etc
- The software used includes the rules of the model that define how the aircraft reacts which includes a database containing information about each airport
- This allows pilots to practice landing at unfamiliar airports
- Control panel in a cockpit is identical to one in real plane and is designed to react in a similar way to a real aircraft
- Pilot uses joysticks and switches to control the movement and speed
- Displays are generated by computers on the screens in the cockpit that display the runway and sky computer graphics
- They displayed using projectors

Learning To Drive A Car

- It is safer to allow drivers to learn how to drive without causing damage to the car or themselves or other drivers and the general public
- The same type of graphics and animation software used for pilot training can be used to reproduce the situations that car drivers experience

- Driving simulators used by driving school usually have a full cab model, which looks like the driver's side of a car and includes real car parts such as clutch, brake pedals, windshield wipers, etc
- Driving simulators replicate actual driving experiences
- They allow you to experience driving at different times of day or night and driving in different weather conditions such as fog, heavy rain and so on
- Driving simulators can also be used to monitor driver behavior, performance and attention span
- The running costs of fuel and tires are greater than the running and maintenance costs of a car driving simulator
- Environmental benefits from driver training in a simulator as there is less pollution created by a driving simulator
- The simulator response however will not always be exactly the same as a car as there are too many variables
- Not every car driving situation can be replicated
- Sometimes drivers become more overconfident after training on the simulator and can go make mistakes in real life leading to car damage or injury
- Amount of stress a car driver would be in heavy traffic is difficult to create
- Initial cost for the simulation development is very expensive

Nuclear Science Research

- Simulator can imitate all the devices in the reactor control room such as meters and sensors
- Computer simulations use mathematical algorithms to predict how different reactors will function
- Testing nuclear reactions using computer models avoid safety concerns such as explosions and meltdowns
- Testing nuclear reactions using computer models cuts down costs as the testing company doesn't have to pay as much for the material
- Results can be obtained in a short period of time regarding reactions that take a long time in real life
- Re-designing computer models is cheaper than re-creating a nuclear reaction
- Researches will have the tools to simulate scenarios that a re hard o observe in operating reactors
- It may be too dangerous o modify the actual nuclear reactor
- Predictions can be easily tested using a computer model for simulation

- Computer model can be designed to allow for extreme conditions such as natural disasters
- However, simulation may not be 100% accurate
- Models can’t aways recreate exactly the real-world experiment
- Not every possible variable may be included in the model to exactly simulate the environment of the nuclear reactor leading to inaccurate results
- It costs money to hire computer experts to create the model